

CYLINDER DEACTIVATION ON TWO DIFFERENT CUBIC CAPACITY ENGINE

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ABSTRACT

Cylinder deactivation is a fuel consumption reduction technology for throttled internal combustion engines and other engines with thermal efficiency loss at part cylinder. Dynamic skip firing, which in its ultimate form incorporates anytime, any-cylinder deactivation, continuously varies the number of firing cylinders, along with cylinder load, obtaining flexible control of acoustic and vibrational excitations from the engine, and allowing an expanded operational envelope with fewer drive ability/NVH issues. This project comprises of two different cubic capacity 4 stroke (150cc-pulsar and 100cc-kinetic) engines coupled with use of sprockets and chains. Even though the cylinder deactivation can also be done by cutting down the fuel supply for any one cylinder depending on vehicle speed, still the deactivated cylinder produces frictional power loss. By adopting this method losses can be avoided and the engine will also run at prefect balanced condition. Thus the engine will be operated at its maximum efficiency and reduce the fuel consumption and emission.

Key words: Two Engine (150cc-Pulsar and 100cc-Kinetic), Coupling of Two Engine, Cylinder Deactivation, Reduce Fuel Consumption.

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1. INTRODUCTION

A petrol engine known as a gasoline engine is an internal combustion engine with spark-ignition, designed to run on petrol (gasoline) and similar volatile fuels. It was invented in 1876 in Germany by German inventor Nicolaus August Otto. The first petrol combustion engine (one cylinder, 121.6 cm³ displacement) was prototyped in 1882 in Italy by Enrico Bernard. In most petrol engines, the fuel and air are usually pre-mixed before compression (although some modern petrol engines now use cylinder-direct petrol injection).

The pre-mixing was formerly done in a carburettor, but now it is done by electronically controlled fuel injection, except in small engines where the cost/complication of electronics does not justify the added engine efficiency. The process differs from a diesel engine in the method of mixing the fuel and air, and in using spark plugs to initiate the combustion process. In a diesel engine, only air is compressed (and therefore heated), and the fuel is injected into very hot air at the end of the compression stroke, and self-ignite.

The four stroke SI engine is a widely applied power source in transportation and other power generation units. However, with the increasing number of such applications, air pollution caused by exhaust emissions has become of primary significance due to its environmental impact. During the past forty years, with the pressure of governmental policies and enormous research activity in this area, the emission (NO_x, CO and HC) levels have been decreased significantly. In the future, a considerable decrease in emission levels due to further improvement in engine technology is expected. Reducing the fuel consumption and related CO₂ emission is increasingly important these days. Typically, internal combustion engines operate more efficiently when the engine load is high. However in daily life, most of the time the engine is operated in lower efficiency region. Better matching of real engine load with optimum engine load can be obtained by applying cylinder deactivation.

With alternatives to the petrol engine being announced ever so often you could be forgiven for thinking that the old favorites the petrol engine is on its last legs but nothing could be further from the truth and possibilities for developing the petrol engines are endless. One of the most crucial jobs on the agenda is to find ways of reducing fuel consumption, cutting emissions of the greenhouse gas CO₂ and also the toxic emissions which threaten air quality. One such fast emerging technology is cylinder deactivation where a number of cylinders are shut down when less is needed to save fuel.

Cylinder deactivation is one of the technologies that improve fuel economy, the objective of which is to reduce engine pumping losses under certain vehicle operating conditions.

When a petrol engine is working with the throttle wide open pumping losses are minimal. But at part throttle the engine wastes energy trying to breathe through a restricted airway and the bigger the engine, the bigger the problem

1.1. Pumping Losses

The four strokes, spark ignition (SI) engine pressure–volume diagram (P–V) contains two main parts. They are the compression–combustion–expansion (high pressure loop) and the exhaust-intake (low pressure or gas exchange loop). The main reason for efficiency decrease at part load conditions for these types of engines is the flow restriction at the cross sectional area of the intake system by partially closing the throttle valve, which leads to increased pumping losses and to increased low pressure loop area on the p–V diagram.

1.2. Need for Cylinder Deactivation

Cylinder Deactivation refers to cutting of fuel supply to selected cylinders in a multi-cylinder engine so that the active cylinders which have fuel supply are operated near to full load. When the engine is operated at part load condition with half the number of cylinders (two cylinders) deactivated, the throttle valve is widely opened compared to normal mode (four cylinders are operated). Hence the pumping loss is reduced in deactivated mode during part load condition. Therefore the total fuel consumption of the engine in deactivated mode is reduced.

DaimlerChrysler, the first manufacturer to hit the U.S. market with a modern cylinder shut-down system calls its approach Multi- Displacement System (MDS). And Honda, who beat everyone to the punch by equipping Japanese-market Inspire models with cylinder deactivation last year, calls the approach Variable Cylinder Management (VCM). The motivation is the same as before improved gas mileage. Disabling cylinders finally makes sense because of the strides achieved in electronic power train controls. According to GM, computing power has been increased 50-fold in the past two decades and the memory available for control algorithms is 100 times greater.

1.3. Methods Used For Cylinder Deactivation

1. Displacement on demand method using Lifter Pin Control Mechanism developed by Delphi Automotive Systems which is an Italy based automobile component manufacturer.
2. Deactivation using Variable Profile Cam shaft developed by Lotus automotive systems. This method is similar to the V tech engines used by the famous automobile manufacturer Honda.
3. Active Valve Train technology (AVT) which does away with camshafts. But this method feasibility and technology is still in experimental stage.

2. DISPLACEMENT ON DEMAND USING LIFTER PIN CONTROL MECHANISM

Principle of Operation:

There are four subsystems in this deactivation hardware system.

1. Electronic control module (ECM)
2. Solenoid valve
3. Hydraulic subsystem
4. Lifter locking pin mechanism

When the solenoid valve in the system is energized, the engine oil pressure increases in the control port. At the same time, the lifters are in continuous contact

with the camshaft. When a lifter is on the cam base circle, the locking pins inside that lifter are free to move. If the control port is pressurized while in this state, then the pressure force acts on the pins, de-coupling the camshaft from the valves. The cylinder deactivation hardware is based on control algorithm which has been developed to characterize the dynamic response of the deactivation system.

2.1. Electronic Control Module

The Electronic Control Module optimizes engine performance by measuring multiple instantaneous events to enable real-time control of the Solenoid valve of Lifter Pin Mechanism. For ECM control purposes, it is crucial to know the dynamic responses of the deactivation hardware system in order to coordinate the deactivation hardware control with other engine control functions. Specifically, the total actuation time is critical for proper design and control of the ECM deactivation system. The total actuation time consists of three elements: the solenoid plunger response time, the hydraulic subsystem response time and the lifter locking pin mechanical response time. Characterization of the total actuation time is not easily achieved given the fact that laboratory testing cannot encompass every possible engine operating condition.

2.2. Solenoid Valve Operation

A 3-way normally closed direct current ON/OFF solenoid valve controls cylinder deactivation. The common port of the control valve is connected via an oil gallery to a pair of spring-biased locking pins inside the valve lifter (a simplified sketch is shown). The common port is then switched to engine oil pressure for deactivation (valve energized) or to engine sump for activation (valve de-energized). Lost motion between the camshaft and the engine valve occurs when engine oil pressure is applied to the spring-biased locking pins inside the lifter, de-coupling the camshaft from the engine valve.

2.3. Locking Pin Mechanism

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The common port of the control valve is connected via an oil gallery to a pair of spring-biased locking pins inside the valve lifter. The common port is then switched to engine oil pressure for deactivation (valve energized) or to engine sump for activation (valve de-energized). Inside the lifter, de-coupling of the camshaft from the engine valve is done. It is desirable to control the switching sequence of the valves cylinder-by-cylinder and to complete the transition between V8 and V4 modes within one engine cycle. These requirements define the switching window of the base circle, the size of which is dependent on the number of cylinders switched at the same time, the cam profile and the firing order of the engine. As the exhaust valve must deactivate/reactivate first, the switching must occur after the intake event begins but before the exhaust event commences.

2.4. Deactivation Using Variable Profile Cam Shaft

This technique was developed by lotus automotive systems that allow the engine to effectively have multiple camshafts. As the engine moves into different rpm ranges, the engine's computer can activate alternate lobes on the camshaft and change the Cams timing. This technique uses a Cam Profile Switching tappet (CPS) to switch between two different Cam profiles.

Cylinder deactivation can be attained by switching between a normal Cam lobe and a plane circular lobe, which does not produce any lift at all. In this way, the engine gets the best features of low-speed and high-speed camshafts in the same engine. This is similar to the patented V-Tech technology used in Honda engines in which whenever the engine speed increases the combustion time reduces in order to keep the combustion time nearly constant. Here the valve should be opened a little earlier than normal condition. This is achieved by the varying the position of the cam shaft which is placed in pressure actuators which is controlled by a microprocessor and electronic circuits. Whenever the engine speed increases these pressure actuators presses or pushes the cam shaft towards the valve lifter. By doing this the valve can be kept opened for a longer time and the valve will be opened more than the usual or normal condition.

1. Magnetic Method
2. Sliding Method
3. Overhead Cam Method
4. Solenoid control method

3. METHODOLOGY

In the present work two engines with different cubic capacity (Bajaj CT 100 cc & pulsar 150cc engine) will be tested for its mileage. In second phase we did disassembling of two engines for cleaning of its parts such as bore, cylinder head, piston, piston head etc., then both engines are assembled accordingly. Now the crankshafts are coupled with the help of sprockets and chains. Performance test is taken for the coupled engine, efficiency and mileage was determined.

3.1. Problem Identification

The concept of cylinder deactivation was implemented in four wheeler vehicles such as Chevrolet Cadillac L62 and then in Mitsubishi. It reduces fuel consumption and emissions only in four wheelers. But this deactivation was not launched in two wheelers by which it causes pollution through emissions and heavy fuel consumption. This concept was introduced with certain modifications in previous concept to reduce the above parameters.

3.2. Engine Identification

Two engines namely Bajaj CT100 and Pulsar 150cc engine was identified for implementing cylinder deactivation.

3.2.1. Base Construction

Chosen base material was Mild Steel and it was constructed according to the structure of the engine dimensions. Electric arc weld was used for welding the base. Voltage for welding ranges from 100-110 V.

1. Frame Channel -28’’*26’’
2. Leg Channel –300 mm
3. Support Channel – 26’’*24’’

3.2.2. Specification of Bajaj CT 100CC Engine

Model Designation Type	Air - Cooled , OHC
Stroke (2/4)	4-stroke
No. of cylinders	Single cylinder
Displacement	97.2 cc
Electrical	12V, 35/ 35 Watt AC
Bore x stroke	50.0 mm x 49.5 mm
No. of Gears	4 - speed constant mesh
Clutch	Multi Plate Wet Type

3.2.3. Specification of Pulsar 150 cc Engine

Model Designation Type	DTS-i, air cooled
Stroke (2/4)	4-stroke
No. of cylinders	Single cylinder
Displacement	149 cc
Max. Power	15.06 @ 9000 (Ps @ RPM)
Bore x stroke	67.0 mm x 62.0 mm
Max. Torque	12.5 @ 6500 (Nm @ RPM)

3.2.4. Engine Mounting And Coupling

One 100cc Engine and 150cc engine was mounted with help of weld plate (MS) and a single shaft was connected using two bearings on the opposite sides. These two engines were coupled to the shaft by means of chain and a sprocket is placed at centre of the shaft to take the power output from both engines and a handle bar is placed between two engines on the opposite side.

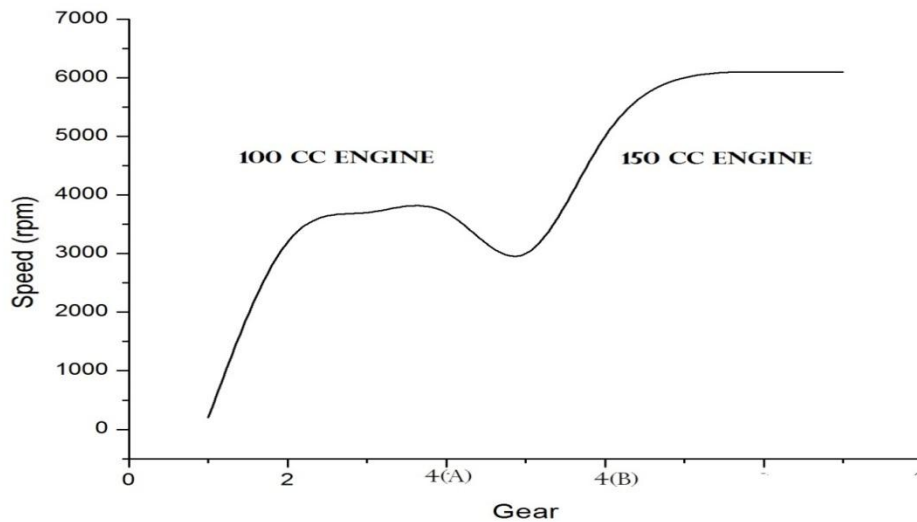
NAME	QUANTITY
100 cc engine	1
150 cc engine	1
Single shaft	1
Sprocket	3
Bearing	2



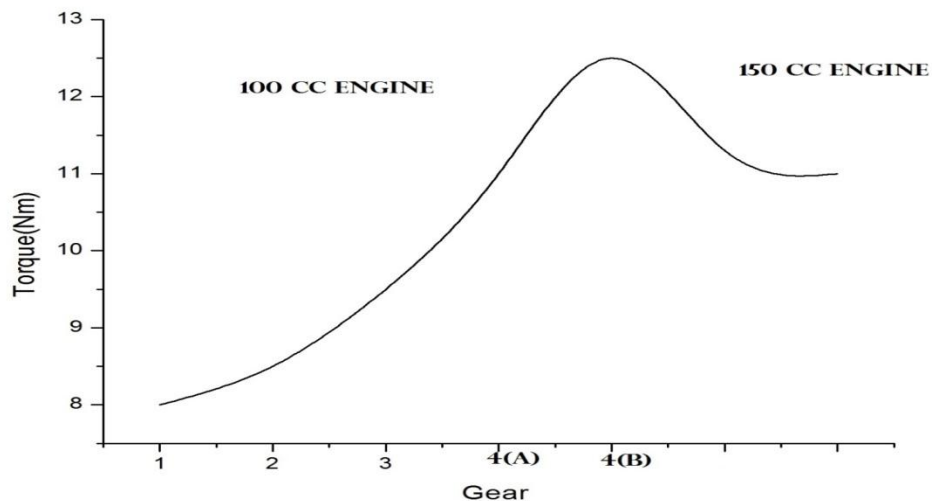
Front and Top View

4. TESTING

After coupling, first 100cc engine was started and made to run at up to its top speed and the power of this engine is shifted to the 150cc engine by making the 100cc to neutral gear. Then these two engines were tested for its mileage and results were determined.



From above graph, 100cc engine was started and made to run at 540rpm at 1st gear, 1600 rpm at 2nd gear, 3280rpm at 3rd gear, 4000rpm at 4th(A) gear and this power shifted to the 150cc engine and made to run at 5226rpm at 4th(B) gear.



From above graph, 100cc engine was started and made to run at torque of 8.5Nm at 1st gear, 8.7 at 2nd gear, 9.2Nm at 3rd gear, 10.5at 4th(A) gear and this power shifted to the 150cc engine and made to run at 12.5Nm at 4th(B) gear.

4.1. Working

Initially 100cc and 150cc engine was started and then 100cc engine is made to run up to its top gear (4th gear). After attaining the maximum torque of 8.5 Nm at a speed 4500 rpm at 4th gear, the power of 100cc engine is shifted to 150cc engine and it is made to run directly at 4th gear attaining a speed of 6500 rpm at maximum torque of 12.5 Nm by making 100cc engine to neutral gear.

If speed of 150cc engine gets reduced at any circumstances, the power of 150cc engine is shifted to 100cc by making 150cc engine to neutral gear.

4.2. Fuel Consumption in Both Engines

S.no.	Engine(cc)	Fuel consumed (ml)	Time taken (sec)	Fuel consumption (ml/sec)
1	CT 100cc engine	10ml	38	0.2631
2	Pulsar 150cc engine	10ml	27.34	0.3657
3	Combined engine	10ml	32	0.3125

5. RESULTS AND DISCUSSIONS

This project was fabricated mainly to test the cylinder deactivation concept in two different CC engines of four strokes and to reduce the fuel consumption and emissions from the engines. By this concept the efficiency of the engine can be increased up to 20%. During cruising and optimum constant load operation the power demanded by the vehicle can be satisfied by minimum no of cylinders as the vehicle does not demand more power which could be delivered by all the cylinders.

Temporarily deactivating cylinders offers an attractive compromise between downsizing an engine to reduce fuel consumption and retaining high levels of comfort and driving pleasure. Even three-cylinder engines can profit from the economic benefits of cylinder deactivation.

Simulations point to the potential that an alternating cylinder deactivation system has for maintaining a balanced temperature level in the engine and reducing vibrations, particularly in three cylinder engine applications. Several options are available for temporarily deactivating valves, especially in the context of finger follower regulation systems. When cylinder deactivation is the only variable aspect required, switchable pivot elements offer a very cost-effective solution without noticeably compromising the basic functions of the valve train assembly. In the case of multi-stage systems or entire engine families, cam shifting systems are more favourable because they can be easily adapted.

6. CONCLUSION

A new valve train system, which differs to the existing design, has been proposed to control cylinder deactivation in SI engines. The novel design is characterized by a simple structure, easy control and can fully meet the strategies of cylinder deactivation control. The use of CTA results in several benefits in improving SI engine efficiency at low engine load. Improvements resulting from CTA will degrade as engine load increases. The two-cylinder deactivation mode considerably improves the fuel consumption at low engine load. Meanwhile the one-cylinder deactivation is an optimal fuel economy mode at medium engine load.

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